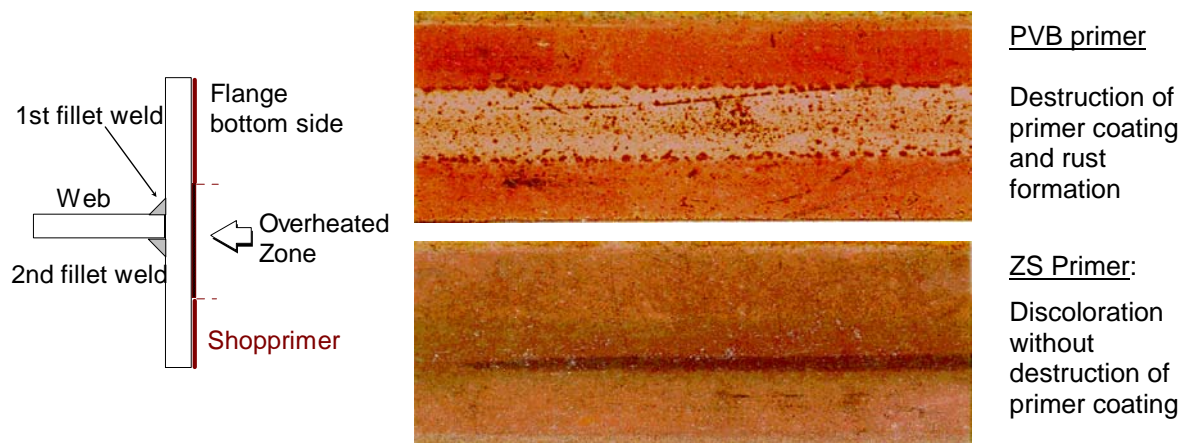


## Qualification of Zinc Silicate Shop Primer ZS 1589 for Welding Through

In order to support our customers in the economic processing of the high-strength steels, the zinc silicate (ZS) shop primer 1589 of Messrs Hempel is used as standard for prefabrication coating of the plates. Its advantages over the previously used PVB shop primer are amongst others:

- a comparable protection period at a significantly reduced coating thickness,
- a higher thermal resistance on account of a minimum of organic constituents which has, for instance, a positive effect on the surface of thinner plates opposite the weld, **Figure 1**,
- high mechanical resistance,
- suitable for constantly water-wetted surfaces and additional cathodic protection, for instance, in shipbuilding and
- clearly reduced susceptibility to pore formation during welding through.



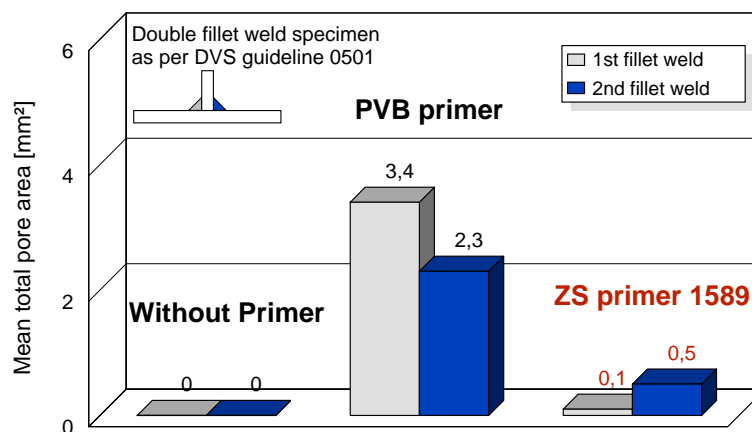
**Figure1:** Corrosion at the bottom side of the double fillet weld samples after one-month outdoor storage

It has to be noted that the new ZS primer can only be removed mechanically by shot blasting or grinding. Grinding will result in increased dust load.

If the primer is to be welded through directly, pore formation has to be expected in the case of fillet welds of the T- or overlap joint on account of the degasification at the root gap. This must be considered in the case of gas-shielded arc welding in particular, because in this process there is a tendency of pore formation at any rate. However, the frequency and size of the pores depend on the type of primer and the coating thickness and is influenced by the welding conditions and the filler metal in addition /1-4/. In contrast to this, hardly any pores appear when welding butt joints and beads on plate.

The qualification of the new ZS primer for through-welding was examined in welding tests. In doing so, different steel grades, filler metals and inert gases were employed. Tests on plates coated with the PVB primer applied until now were used for comparison. The thickness of the coating with ZS primer was only approx. 15  $\mu\text{m}$  and in the case of PVB primer approx. 20  $\mu\text{m}$ , which corresponds to a comparable period of protection.

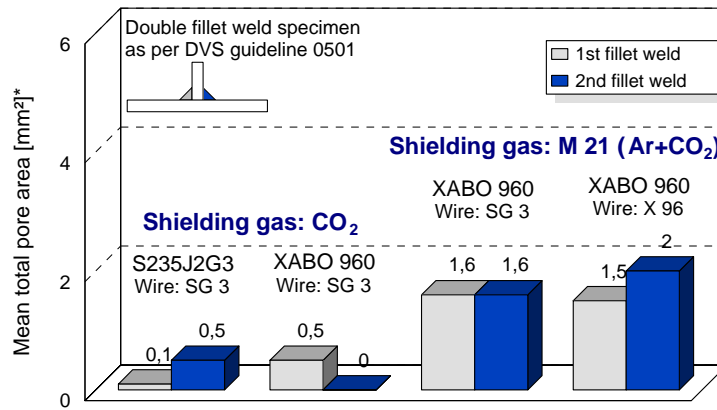
The tests for evaluating the tendency to pore formation were carried out in the form of coupon plates according to DVS welding guideline 0501, Appendix 5 /5/. The double fillet weld specimen were fabricated according to the gas-shielded arc process with an throat thickness of 4 mm. For reasons of comparability, the welding parameters were kept constant for all tests because a higher welding speed or a higher voltage can promote pore formation. For each test condition, at least three coupon plates were welded. After the web plate had been cut off, a radiographic examination was carried out and the total pore area related to 125 mm long weld sections was determined in accordance with the guideline. Each coupon plate had 4 measuring sections.



**Figure 2:** Comparison of PVB and zinc silicate shop primers  
(base metal: S235J2G3, wire electrode: SG 3, shielding gas: CO<sub>2</sub>)

The mean total pore area is less than 5 mm<sup>2</sup> on all weld test specimen, which corresponds to a rating figure from 0 to 1 on the scale from 0 (= 0 mm<sup>2</sup>) to 10 (> 320 mm<sup>2</sup>) determined in the DVS guideline 0501. **Figure 2** shows a comparison of the total pore areas when welding through the PVB primer used until now and the new ZS primer 1589. In this context, the more favourable behaviour of the ZS primer 1589 is striking.

As can be seen from **Figure 3**, any influence of base metal and filler metal on pore formation when welding through the zinc silicate shop primer 1589 cannot be observed under the general conditions selected here. The highest weld quality was obtained with the MAG process using pure CO<sub>2</sub>, a relatively highly oxidising shielding gas.

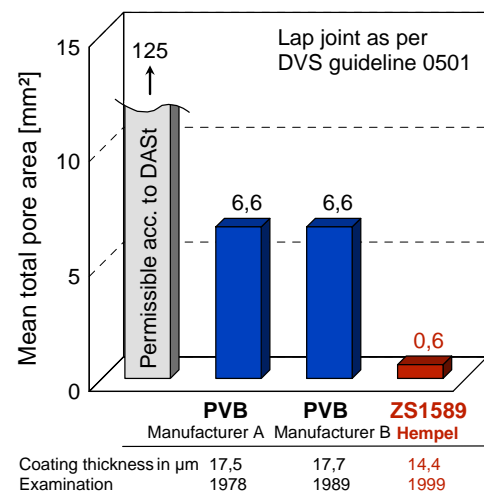


**Figure 3:** Influence of shielding gas, base metal and filler metal on the tendency to pore formation when welding through the zinc silicate shop primer 1589

When using the mixed gas M 21, which is, for instance, commonly used in crane fabrication, the X-ray examination revealed a greater pore area according to tendency which, however, attains the very good rating figure 1 as well with a maximum of 2 mm<sup>2</sup>.

The investigations of the Force Institute /6/ and the SLV Duisburg /7/, **Figure 4**, yielded comparable results. The zinc silicate shop primer 1589 excels by an only insignificant low pore formation at welding through and meets the conditions for approval by the DAST. Moreover, it features clear advantages over the PVB primer used until now.

According to these examinations, the minor zinc proportion has no significant influence on the weldability, but results in a clear improvement of the corrosion behaviour.



**Figure 4:** Investigations of the SLV Duisburg

FQP-FB-Schweißtechnik  
 Duisburg, 14.09.2000

**Bibliography:**

- /1/ Potthoff, F. u.a.: Zur Frage der Porenbildung von Fertigungsbeschichtungen. *Schweißen und Schneiden* 27 (1975), H. 11
- /2/ Pattee, H. E. und R. E. Monroe: Effect of Protective Coatings on Weldability. *Welding Research Supplement* 48 (1969), H. 6
- /3/ Arndt, K.: Schweißen auf vorkonservierten Bauteilen. *Schweißtechnik (Berlin)* 17 (1967), H. 11, S. 495 - 498
- /4/ Otto, J.: Einflüsse beim Überschweißen von Fertigungsbeschichtungen. *Schweißen und Schneiden* 28 (1976), H. 5
- /5/ Richtlinie DVS 0501: Prüfen der Porenneigung beim Überschweißen von Fertigungsbeschichtungen auf Stahl. (März 1976)
- /6/ Test of the Hempel's Shopprimer ZS 15890 in accordance to DVS 0501. Force Institute Denmark (1993)
- /7/ Prüfen der Porenneigung Hempel's Shopprimer ZS 15890. Untersuchungsbericht der SLV Duisburg Nr. 9934081/1 (1999)



## **FUME AND GAS EMISSION RATES ASSOCIATED WITH FCA WELDING AND FLAME CUTTING OF PLATES COATED WITH HEMPEL ZS 15890 SHOP PRIMER (copy)**

At the request of Hempel's Skibsfarvefabrik A/S the FORCE Institute has measured the fume and gas emission rates associated with FCA welding and flame cutting of plates coated with Hempel ZS 15890 in order to evaluate whether the decomposition products from the primer constitute a health risk compared to welding and cutting in shot blasted plates.

The tests were part of the investigations within the Nordic project NI-P92035 "Welding of shop primed plates" (ref. 1). The results for ZS 15890 shop primer have furthermore been reported in two separate reports for welding and cutting respectively (ref. 2 and 3).

The investigation was based on comparative tests in shot blasted plates and primed plates respectively. The technique used to measure the fume and gas emission rates was the fume box method in accordance with the draft for CEN standard for emission rate measurements in welding and allied processes.

Primer film thickness on the test plates was measured to approx.  $21 \pm 5 \mu\text{m}$

### **Summary of test results**

#### **a. Welding**

Welding was performed as horizontal-vertical fillet welding using FCA welding with 1.2 mm diameter metal cored wire at 285 amps and shielding gas 82 Ar/18 CO<sub>2</sub>.

The test results showed that welding on Hempel ZS 15890 shop primer increases the fume emission rate and the zinc content in the fume compared to welding on shot blasted plate. The emission rates of gases were very low and without hygienic significance.

The increase in fume emission rate and zinc content in the fume due to ZS 15890 correspond to an increase in NHL-value of approx. 4800 m<sup>3</sup>/h compared to welding on non-coated material.

This increase in NHL-value is of the same magnitude as normally found for shop primers. Furthermore, the increase is within the range of variations in NHL-value due to the welding process itself and, consequently, the normal ventilation requirements for the welding process can be considered as sufficient for welding on the primer in the recommended coating thickness.

#### **b. Flame cutting**

Flame cutting tests were performed in 10 mm shot blasted mild steel plates as well as plates coated on both sides with ZS 15890 using acetylene-oxygen cutting.

The measurements showed that cutting in plate material coated with Hempel ZS 15890 shop primer resulted in a reduction of the total fume emission rate compared to flame cutting in shot blasted plate but at the same time the zinc content

in the fume was higher than for shot blasted plate. The emission rates of gases during cutting in the primer were of the same magnitude as for shot blasted material.

The combined effect of the reduction in fume emission rate and the increase in zinc content was a reduction in the NHL-value of approx. 2400 m<sup>3</sup>/h for cutting in primed material compared to shot blasted material.

This result is in agreement with the experiences from previous preliminary investigations of the effects of shop primers on the fume and gas emission rates in flame cutting (ref. 4). The total results show that the ZS 15890 shop primer decomposes during flame cutting and contributes to the fume and gas emission rates, including an increase in the zinc content in the fume, but at the same time the cutting process itself is influenced by the primer in such a way that the fume emission rate from the process in general is reduced compared to cutting in shot blasted material.

The test results are described in details in ref. 1, 2 and 3.

#### References

- (1) Welding of shop primed plates. NI-project P92035.  
Report 94.53, FORCE Institute 1994.
- (2) Investigation of the fume and gas emission rate associated with FCA welding on plates coated with Hempel ZS 15890 shop primer.  
FORCE Institute report, July 1997, at the request by Hempel's Skibsfarvefabrik A/S.
- (3) Investigation of the fume and gas emission rate associated with flame cutting in plates coated with Hempel ZS 15890 shop primer.  
FORCE Institute report, July 1997, at the request by Hempel's Skibsfarvefabrik A/S.
- (4) Flammeskæring med naturgas, propan og acetylen, arbejdshygiejniske målinger.  
Report 87.51, FORCE Institute